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(54) Membrane filter process and apparatus for the purification and/or treatment of suspensions of precious metal compounds

(57) The invention relates to a process for the purification and/or treatment of suspensions, which include at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or solid and/or also in dissolved form, which includes the following steps:

- concentrating or thickening the precipitate or solid in the suspension by removal of the liquid phase by means of a membrane filter apparatus, whereby dissolved impurities and/or precious materials are discharged with filtrate;
- washing of the concentrated or thickened suspension by addition of a wash liquid and removal of filtrate by means of the membrane filter apparatus, whereby the concentration or thickening of the solids in the suspension does not or changes only slightly during washing and the concentration or thickening of the dissolved impurities and/or precious materials still present in the suspension are reduced to a pre-determined value; and
- complete drainage of the membrane filter apparatus to provide, in purified form, solid and/or purified precipitates of the precious metal(s) and /or rare earths or other elements remaining in residual suspension for further treatment and/or further application.

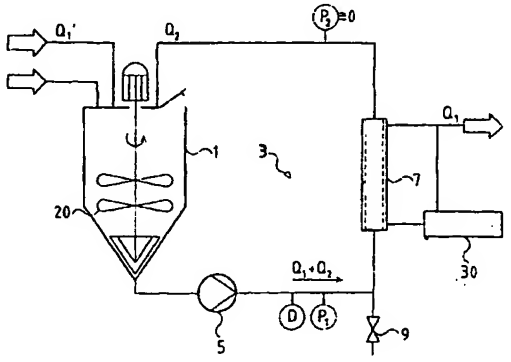

FIG. 1

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Description

FIELD OF INVENTION

[0001] The invention relates to a process and an apparatus for the purification and/or treatment of suspensions, which contain at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or sediment.

BACKGROUND TO INVENTION

[0002] During the manufacture of pure precious metals and/or rare earths and/or other elements of the Periodic System or their salts, the precious metal or the rare earth or the element is dissolved in a corresponding suitable solvent. In addition to the specific element or precious metal, other elements, which are similar regarding the dissolving behaviour, normally also dissolved and this can constitute impurities.

[0003] By adding precipitating agents specifically suited to the respective element or regulation of the solution equilibrium with a corresponding buffer solution or pH-shift, it is possible to selectively precipitate from the solution the desired individual elements or precious metals or rare earths. This results in a suspension, which contains the deposited precipitate or the solid as well as the materials still remaining in the solution.

[0004] To obtain the desired precious metal and/or element in purest form, it is necessary to purify the desired deposited precipitate present in the suspension.

[0005] According to the state of the art, the washing and purification of such precipitated precious metals from the suspension occur in so-called glove-boxes, in which the liquid phase moves through a filter medium by application of a vacuum, which becomes quickly covered and impermeable due to the extreme fine solids: To prevent this the solution is stirred manually. To wash about 10 kg of platinum hydroxide with such a process about 10 to 15 working days are needed.

[0006] A further disadvantage of such processes with glove boxes is the burden on the environment.

[0007] Object of the invention is thus to provide a process and an apparatus by means of which these disadvantages can be prevented. Particularly, the washing should occur in a closed-system in the process in accordance with the invention, least possible washing liquid is required and the washing of quantities in the region of for example 10 kg of platinum occurs in the shortest possible time, preferably in less than one working day.

SUMMARY OF INVENTION

[0008] According to the invention, a process for the purification and/or treatment of suspensions, which include at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or solid and/or also in dissolved form, includes the following steps:

1. concentrating or thickening the precipitate or solid in the suspension by removal of the liquid phase by means of a membrane filter apparatus, whereby dissolved impurities and/or precious materials are discharged with filtrate;

2. washing of the concentrated or thickened suspension by addition of a washing liquid and removal of filtrate by means of the membrane filter apparatus, whereby the concentration or thickening of the solids in the suspension does not or changes only slightly during washing and the concentration or thickening of the dissolved impurities and/or precious materials still present in the suspension are reduced to a pre-determined value; and

3. complete drainage of the membrane filter apparatus to provide, in purified form, solid and/or purified precipitates of the precious metal(s) and/or rare earths or other elements remaining in residual suspension for further treatment and/or further application.

[0009] The invention therefore proposes that the solids contained in the suspension or the precipitate initially are concentrated or thickened by removing the liquid phase of the suspension by means of a membrane filter apparatus, whereby the dissolved impurities and/or precious materials are carried out with the filtrate. By means of the concentration or the thickening, the concentration of the solid or precipitate is increased in the suspension. After reaching the maximum possible reduction of the starting volume, the suspension is washed by addition of a washing liquid and the removal of the filtrate by means of the membrane filter apparatus. Thereby the dissolved impurities and/or precious metals or elements remaining in the solution are reduced to a predetermined value. To improve the efficiency of the washing the liquid can also contain additives or buffer solutions.

[0010] After the washing of the suspension containing the insoluble precipitate, the membrane plant is completely

drained. The desired product, i.e. the purified precipitate of the precious metal(s) and/or rare earths or other elements are then available in highest purified form for further application or further processing.

[0011] The process according to the invention is suitable, in particular, for recovering one or more of the following elements: gold, platinum, rhodium, palladium, ruthenium, iridium, osmium, cobalt, europium, lanthanum, germanium, gallium, cerium, tantalum, niobium, selenium, tellurium, cadmium, bismuth, beryllium, uranium, manganese, in highest purified form as precipitate or in dissolved form.

[0012] The washing liquids are appropriately chosen according to the specific chemical behaviour of the element to be scrubbed out.

[0013] In particular, the washing liquid may contain acetic acid and/or ammonium nitrate and/or sodium carbonate or sodium bicarbonate and/or hydrochloric acid and/or nitric acid and/or aqua regia.

[0014] In a preferred embodiment form, it is provided that the concentration of the impurities still dissolved in the liquid phase of the suspension after scrubbing, lies in the range of 50 mg per litre to 0,001 mg per litre.

[0015] The process temperature of both the concentrating and also the washing by means of the membrane filter apparatus lies in the range of 5°C to 150°C, during the treatment of rhodium hydroxide preferably between 75°C and 85°C and during the treatment of platinum hydroxide preferably between 40°C and 50°C.

[0016] Preferably, the membrane filter apparatus used for the concentrating and washing, is operated according to a tangential flow filtration process, i.e. the membrane, which serves as filter body, is over flowed over by a continuous speed tangential to the membrane surface, so that deposits of materials on the membrane surface are substantially prevented by the tangential flushing.

[0017] Impurities, which deposit in the pores despite the flowing over, can be removed from the membrane surface by the introduction of a back flush impulse during the operation. Such a back flush impulse removes large impurities from the surface of the membrane by mechanical separation.

[0018] The nominal pore size of the membranes of the membrane filter apparatus may be in the range between 5 nm and 1,4 µm, whereby specially preferred are membranes with a separating size of 50 to 100 nm.

[0019] Membranes of ceramics, polymeric materials, metal or inorganic materials may be used as membranes in the membrane filter plant. Especially preferred is the use of ceramic membranes or membranes of other inorganic materials due to their high chemical and physical stabilities.

[0020] The operating pressure in the membrane filter apparatus or its modules lies in the range of 0,5 to 50 bar, preferably in the range of 2 to 6 bar.

[0021] Also according to the invention there is provided an apparatus for the operation of a process as set out herein, characterised thereby,
that the apparatus includes:

at least one pre-tank, and

at least a membrane filter apparatus.

[0022] The apparatus for the operation of the process is therefore characterised thereby, that it includes at least one storage apparatus or pre-tank, in which the suspension to be treated is introduced and thickened, as well as a membrane filter apparatus with which the concentrating and washing can take place. A very decisive advantage lies therein that the filter apparatus in an embodiment of the invention is constructed in such a way, that it can be completely drained by gravity or positive gas pressure. This ensures that no residues remain in the pump sump after emptying and a product in highest purified form can be removed from the plant as slurry/suspension.

[0023] For impurities of the membrane filter apparatus, which cannot be removed by mechanical back pulse, it is advantageous if the membrane filter apparatus is provided with a cleaning apparatus, which makes it possible to introduce cleaning liquid to the membrane module(s), which chemically dissolves the absorbate layers deposited on the membranes. Chemical cleaning substances for this are, for example, acetic acid or hydrochloric acid or nitric acid or aqua regia or HF-acids. For example, HF-acids are used to dissolve polymeric silicic acid.

[0024] Concerning the different purification processes of membrane modules in membrane filter apparatus, reference is made to WO 99/42203, the contents of which is considered to be fully incorporated in the present application.

[0025] In a first embodiment form, the membrane filter apparatus can consist of one membrane module. Alternatively, the membrane apparatus can also include a number of membrane modules, which are located either in series or parallel. These membrane modules can either be back flushed together or individually.

[0026] In a further embodiment of the invention, it is provided that the membrane filter apparatus consists of several in series arranged membrane loops, which can be removed individually from the operation and/or be back flushed individually or together.

BRIEF DESCRIPTION OF DRAWINGS

[0027] The invention will now be described by way of example with reference to the accompanying schematic drawings.

[0028] In the drawings there is shown in:

Figure 1 A schematic illustration of an open cycle with a reservoir container and a membrane filter apparatus, including a membrane module, in accordance with the invention;

Figure 2 A modified semi-open system for batch operation including a pre-tank or reservoir container, a membrane filter apparatus with a membrane module and a membrane cycle in accordance with the invention; and

Figure 3 A system with pre-tank and agitator located therein as well as a membrane cycle in accordance with the invention.

DETAILED DESCRIPTION OF DRAWINGS

[0029] The invention will now be explained for the two materials rhodium and platinum by means of two examples.

Example 1:

[0030] Rhodium hydroxide is the starting material for a number of rhodium salt solutions, for example rhodium sulphate, rhodium nitrate or rhodium phosphate. Rhodium hydroxide is normally obtained by treating a solution of hexachloro-rhodate with sodium hydroxide. The resulting sediment or the resulting precipitate of rhodium hydroxide is contaminated with the reaction by-product sodium chloride. The reaction is as follows:

$$H_3RhCl_6 + 6NaOH \longleftrightarrow Rh_2O_3.xH_2O + 6NaCl$$

[0031] With the process in accordance with the invention impurities, particularly the sodium chloride can be efficiently removed from the suspension, which contains the precipitated rhodium hydroxide. In addition, the suspension containing the rhodium hydroxide precipitate is concentrated in accordance with the invention and being water containing ammonium nitrate as washing liquid the sodium chloride impurities are removed by means of the membrane filter technique.

[0032] In particular, the NaCl-impurities, which are present on the particles of the rhodium hydroxide even after the removal of the liquid phase of the suspension during the thickening, can be eliminated by means of the washing. This is decisive to obtain the desired high-purified rhodium salt and/or to be able to produce it later.

Example 2:

[0033] Platinum hydroxide is a starting material for a number of platinum salt solutions for example platinum nitrate. Platinum hydroxide is obtained by treatment of a solution of potassium or sodium hexachloroplatinate with potassium or sodium hydroxide and the subsequent neutralisation of the solution with acetic acid. The precipate resulting from this is extremely fine and correspondingly difficult to wash out.

[0034] The reaction is as follows:

$$K_2PtCl_6 + 6KOH \longleftrightarrow K_2Pt(OH)_6 + 6KCl$$

$$K_2Pt(OH)_6 + 6KCl + 2CH_3COOH \longleftrightarrow PtO_2.4H_2O + 2KCOOCH_3 + 6KCl$$

[0035] In the suspension with the platinum hydroxide precipitate, both potassium acetate as well as potassium chloride are contained as impurities. By means of the process according to the invention, the suspension containing the platinum hydroxide precipitate can be concentrated by means of a membrane filter plant and the impurities dissolved in the liquid phase, for example potassium acetate and potassium chloride, can be reduced by washing with a suitable aqueous scrubbing liquid, which can also contain acetic acid, after the concentrating by means of the membrane filter plant to a predetermined degree.

[0036] In addition to the above describe purification techniques of suspensions with the help of a membrane filter apparatus, in which initially the solid material is concentrated in the suspension and subsequently the impurities are washed out, it is also possible, to use a membrane filter apparatus for the separation of a specific element and/or several elements from a suspension containing a number of elements. In such a case, the desired product leaves the membrane filter in the permeate in dissolved form, however the solid materials remain in the retentate. With such a process, the washing then has the object to wash out the desired, dissolved element or the desired dissolved elements from the slurry or the suspension. The solids remaining in the slurry can be removed from the membrane filter apparatus or be dissolved out of the membrane filter apparatus by means of a suitable solvent, or after the dissolving and washing out of an element or several elements, the process can be repeated with a specific solvent suitable for other elements in the virtually closed system.

[0037] The following embodiment example should serve as an example for such an application of a membrane filter plant:

Example 3:

[0038] One of the first steps during the production of platinum is, for example, the dissolving of a metal ore in a suitable solvent. The solution contains then for example platinum, palladium, rhodium, ruthenium, iridium and osmium as well as a number of further metallic elements. To separate platinum from this solution, the solution is treated with sodium bromate. This causes that all the above-mentioned metals, with the exception of platinum, precipitate as a "bromate mud". This bromate slurry can only be filtrated or purified with great difficultly and contains in its liquid part normally a considerable amount of platinum. By means of a membrane filter apparatus platinum, which lies dissolved in the liquid phase, can be separated from the slurry or the suspension. Therewith it is possible, to recover all the platinum dissolved in the suspension by means of the membrane filter apparatus. Furthermore, the slurry remaining in the membrane filter can repeatedly be treated with corresponding solvents. This enables, for example, the separation of the insoluble osmiums and rutheniums from the rest of the metals, in that the metals dissolved in the suitable solvents passed through the membrane filter with the permeat, while the insoluble osmium and ruthenium remain in the non-filtered residue. Aqueous solutions, which can contain sodium carbonate or sodium bi-carbonate or their ammonium compounds, can be used as washing liquid of this bromate sediment.

[0039] Hereafter a membrane filter apparatus, which is suitable for the operation of the process in accordance with the invention, is described. The apparatus for the operation of the process includes a reservoir container or pre-tank 1, in which, for example, the suspension to be purified is introduced. The pre-tank 1 can include optionally a stirring device as depicted in Figure 3. From the pre-tank 1 the liquid phase is supplied to the membrane filter apparatus 3. The membrane filter apparatus 3 includes a pump 5, which transfers the liquid phase from the reservoir container 1 to the membrane module 7. The membrane module 7 is provided in the present embodiment form with ceramic membranes or membranes of other inorganic materials with a nominal pore size of for example 5 to 1 400 nm.

[0040] The membrane filter apparatus in the present case is operated according to the principle of tangential flow filtration. The tangential flow filtration is characterised by the presence of two volume streams, a stream Q_1 at speed V_1 of the filtrate perpendicular to the membrane surface, the so-called permeate speed, and a stream Q_2 at speed V_2 tangential to the membrane surface, the so-called cross flow speed. The volume stream Q_1 determines the filter or the permeate output and the volume stream Q_2 the cross flow volume, which substantially prevents the deposit of materials on the membrane surface by tangential flushing. With the process in accordance with the invention, a large part of the liquid phase of the suspension is removed as permeat during the concentrating step. By the continuous removal of the permeat with the volume stream Q_1 the liquid phase in the suspension is continuously reduced, so that the solids concentrate in the present suspension.

[0041] After the volume of the suspension has been reduced to the smallest possible value, washing liquid is added to wash out the dissolved material. To this a volume stream of wash liquid Q^I_1 is added, whereby the middle volume stream of the added wash liquid in an embodiment form corresponds exactly with the average flow rate of the permeat removed over the membrane filter apparatus. By continuous addition of renewed wash liquid Q^I_1 the concentration of dissolved materials and/or the impurities in the liquid phase of the concentrated suspension is continuously reduced to a predetermined value.

[0042] If the predetermined purification degree has been achieved, the addition of wash liquid is terminated and the complete membrane plant is completely drained by means of valve 9. Hereby it is achieved, that no residues remain in the membrane filter apparatus and in the storage container and that the product is present in highest purified form as solid in the discharge container, in which the total suspension/slurry is completely discharged by gravity and/or by blowing out with suitable gas under positive pressure.

[0043] In Figure 2, an alternative configuration for the operation of the process in accordance with the invention is illustrated. Same component parts as in Figure 1 are identified with the same reference numerals.

[0044] In contrast to Figure 1, the membrane filter apparatus 3 includes a closed-cycle 10 in which the volume stream

Q_2 - Q_3 is continuously stirred by means of a pump 12. The cross flow volume is again the stream Q_2. The stream Q_3 is returned as retentate to the reservoir container 1. By continuous removal of the permeat with the volume stream Q_1 the suspension is again concentrated. After the completion of the concentrating step, washing liquid is added as in the process according to Figure 1, with the average flow rate Q^I_1.

[0045] By addition of the wash liquid, the concentration of the materials and/or impurities dissolved in the suspension is continuously reduced, until a pre-determined value is reached, whereby the remaining dissolved impurities and/or materials lie preferably in the range of 50 mg per litre up to 0,001 mg per litre. Then the total plant is drained again via valve 9 and the concentrated solid with the suspension/slurry is removed in highest purified form.

[0046] In Figure 2, the continuous circulation of the volume stream Q_2 - Q_3 takes place by means of the pump 12. In the arrangement in Figure 2, a pressure P_2 at the outlet of the membrane module is maintained by the pump 6. The pressure difference between the inlet to the membrane module 7 and the outlet from the membrane module is therewith $\Delta P = P_1 - P_2$.

[0047] In the system according to Figure 1, the pressure P_2 at the outlet is about 0, that means the pressure difference ΔP over the membrane module is P_1 - P_2, whereby this pressure P_1 is created solely by the pump 5, which also causes the tangential cross flow of the membrane.

[0048] If the membrane apparatus illustrated in Figure 1 and Figure 2 is used therefore, for example to filter out platinum from a mixture, then the elements mentioned in embodiment example 3 except, for example, the platinum remaining in the solution, can be precipitated by a suitable precipitation agent. The liquid phase, containing the platinum to be recovered, is fed to the membrane filter apparatus as in the case of purification of a suspension. The metal to be recovered is then contained in the liquid phase removed as pemeat, the solids to be removed remain in the retentate.

[0049] By addition of suitable solvents, the desired elements can be successively converted to the dissolved form out of the solids present in the pre-tank 1 or in the membrane cycle and be removed by means of the membrane filter apparatus in the permeate.

[0050] In Figure 3, a modified construction of a membrane filter apparatus for the operation of the above described process is illustrated. Once again, the apparatus includes a pre-tank 1, which includes an agitator 20 for stirring of the suspension introduced to the pre-tank 1. From the pre-tank 1, the suspension contained in the reservoir container 1 is transferred by means of the pump 6 via conduit 24 to the membrane filter apparatus 3. The membrane filter apparatus 3 includes a membrane module 7, which is preferably provided with ceramic membranes or membranes of other inorganic materials. A pump 12 is provided for the circulation of a predetermined volume flow in the membrane cycle 10 and a heat exchanger 24 arranged in the membrane cycle, which is served by a heat transfer liquid, enables the removal of heat from/or the addition of heat to the product cycle. The retentate is furthermore added via conduit 26 to the reservoir container 1, the permeat is removed via conduit 28. For purification of the membrane module 7, the apparatus is provided, in accordance with Figure 3, with a back flush apparatus 30. By introduction of a back flush impulse impurities deposited on the membrane surface can be mechanically removed.

[0051] When the washing procedure is completed, the total plant can be drained by valve 9, which is arranged in such a way, that the total plant can run completely empty, so that the highly purified solid is present in the discharge container connected after or inserted after the valve 9. The addition of washing liquid, which corresponds essentially to the average permeate flow rate, takes place via conduit 34.

[0052] With the present invention and the present process a first possibility is provided to obtain precious metals or their precipitates, in particular of platinum, rhodium or ruthenium, in a closed-system in high purified form with impurities, which are less than 50 mg per litre to 0,001 mg per litre. The wash times can be considerably reduced and due to the treatment in a virtually closed-system, both the environmental influence as well as the danger of the leaking of precious metals or rare earths or other precious materials can be reduced.

Claims

1. Process for the purification and/or treatment of suspensions, which include at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or solid and/or also in dissolved form, which includes the following steps:

   1.1 concentrating or thickening the precipitate or solid in the suspension by removal of the liquid phase by means of a membrane filter apparatus, whereby dissolved impurities and/or precious materials are discharged with filtrate;

   1.2 washing of the concentrated or thickened suspension by addition of a wash liquid and removal of filtrate by means of the membrane filter apparatus, whereby the concentration or thickening of the solids in the suspension does not or changes only slightly during washing and the concentration or thickening of the dissolved

impurities and/or precious materials still present in the suspension are reduced to a pre-determined value; and

1.3 complete drainage of the membrane filter apparatus to provide, in purified form, solid and/or purified precipitates of the precious metal(s) and/or rare earths or other elements remaining in residual suspension for further treatment and/or further application.

2. Process according to claim 1, characterised thereby, that the precious metals and/or rare earths or elements include one or more of the following elements: gold, platinum, rhodium, palladium, ruthenium, iridium, osmium, cobalt, europium, lanthanum, germanium, gallium, cerium, tantalum, niobium, selenium, tellurium, cadmium, bismuth, berryllium, uranium, manganese.

3. Process according to claim 1 or claim 2, characterised thereby, that an aqueous solution, which is adapted to the specific chemical action of the elements to be washed out, is used as wash liquid.

4. Process according to claim 3, characterised thereby, that the wash liquid includes acetic acid and/or ammonium nitrate and/or sodium carbonate/sodium bicarbonate and/or hydrochloric acid and/or nitric acid and/or aqua regia.

5. Process according to any one of the claims 1 to 4, characterised thereby, that the concentration or thickening of impurities and/or valuable materials, still dissolved in the liquid phase of the suspension after washing, lies in the range of 50 mg per litre to 0,001 mg per litre.

6. Process according to any one of the claims 1 to 5, characterised thereby, that permeate/filtrate contains the valuable materials in dissolved form.

7. Process according to any one of the claims 1 to 6, characterised thereby, that its process temperature of the process lies in the range of 5°C to 150°C, preferably between 75°C to 85°C during treatment of rhodium precipitate and preferably between 40°C to 50°C during treatment of platinum precipitate.

8. Process according to any one of the claims 1 to 7, characterised thereby, that the membrane filter apparatus includes a membrane loop and a pre-tank, that for the maintaining of its process temperature, at least one heat exchanger is used, which is arranged either directly in the membrane loop or at the inlet of a membrane loop or return of the membrane loop to a pre-tank.

9. Process according to claim 8, characterised thereby, that the pre-tank is provided with a temperature regulating device or piping is designed to be at least partially temperature controlled.

10. Process according to any one of the claims 1 to 9, characterised thereby, that the concentrating or thickening and washing occurs by means of a membrane filter apparatus, which is operated according to a tangential flow filtration process.

11. Process according to claim 10, characterised thereby, that a back flushing of the membrane filter apparatus takes place in predetermined time intervals.

12. Process according to any one of the claims 1 to 11,

characterised thereby,
that the membrane filter apparatus is operated with membranes having a nominal pore size in the range of between 5 nm up to 1,4 µm, whereby preferably membranes with a pore size of 50 to 100 nm are used.

13. Process according to any one of the claims 1 to 12,
characterised thereby,
that the membrane filter apparatus has membranes manufactured from ceramic, polymeric materials, metal or other inorganic materials, whereby ceramic membranes or membranes of other inorganic materials are preferably used due to their wide chemical and high physical stabilities.

14. Process according to any one of the claims 1 to 13,
characterised thereby,
that the operating pressure in the membrane filter apparatus lies in the range of 0,5 to 50 bar (0,05-5 MPa), preferably in the range of 2 to 6 bar (0,2-0,6 MPa).

15. Apparatus for the operation of a process according to any one of the claims 1 to 14,
characterised thereby,
that the apparatus includes:

at least one pre-tank, and

at least a membrane filter apparatus.

16. Apparatus according to claim 15,
characterised thereby,
that the membrane filter apparatus is constructed in such a way that the apparatus is adapted to be completely drained by means of gravity and/or positive gas pressure.

17. Apparatus according to claim 15 or claim 16,
characterised thereby,
that the membrane filter apparatus includes a cleaning apparatus for supply of cleaning liquids to the membrane filter apparatus.

18. Apparatus according to any one of the claims 15 to 17,
characterised thereby,
that the membrane filter apparatus consists of several membrane modules arranged in series and/or parallel, which can be back flushed together and/or individually.

19. Apparatus according to any one of the claims 15 to 17,
characterised thereby,
that the membrane filter apparatus consists of several membrane cycles arranged in series or parallel, which can be taken out of operation individually and/or be back flushed individually or together and/or be drained individually or together.

20. Use of an apparatus, including at least one pre-tank as well as at least one membrane filter apparatus for the separation of one or more of the following precious metals and/or elements and/or rare earths:
gold, platinum, rhodium, palladium, ruthenium, iridium, osmium, cobalt, europium, lanthanum, germanium, gallium, cerium, tantalum, niobium, selenium, tellurium, cadmium, bismuth, beryllium, uranium, manganese.

21. Process for the purification and/or treatment of suspensions, which include at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or solid and/or also in dissolved form substantially as hereinbefore described with reference to and as illustrated in the accompanying schematic drawings.

22. An apparatus for the purification and/or treatment of suspensions, which include at least one or more precious metals and/or rare earths or other elements in the form of a precipitate or solid and/or also in dissolved form substantially as hereinbefore described with reference to and as illustrated in the accompanying schematic drawings.

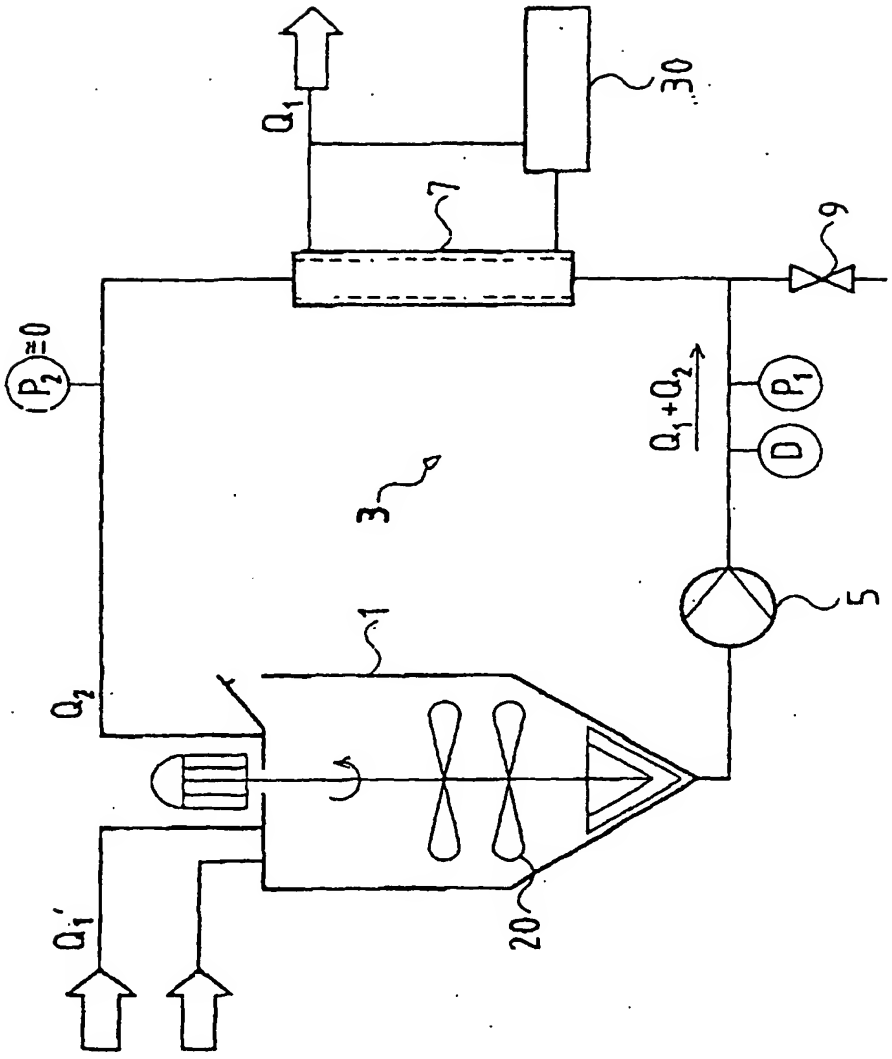

FIG. 1

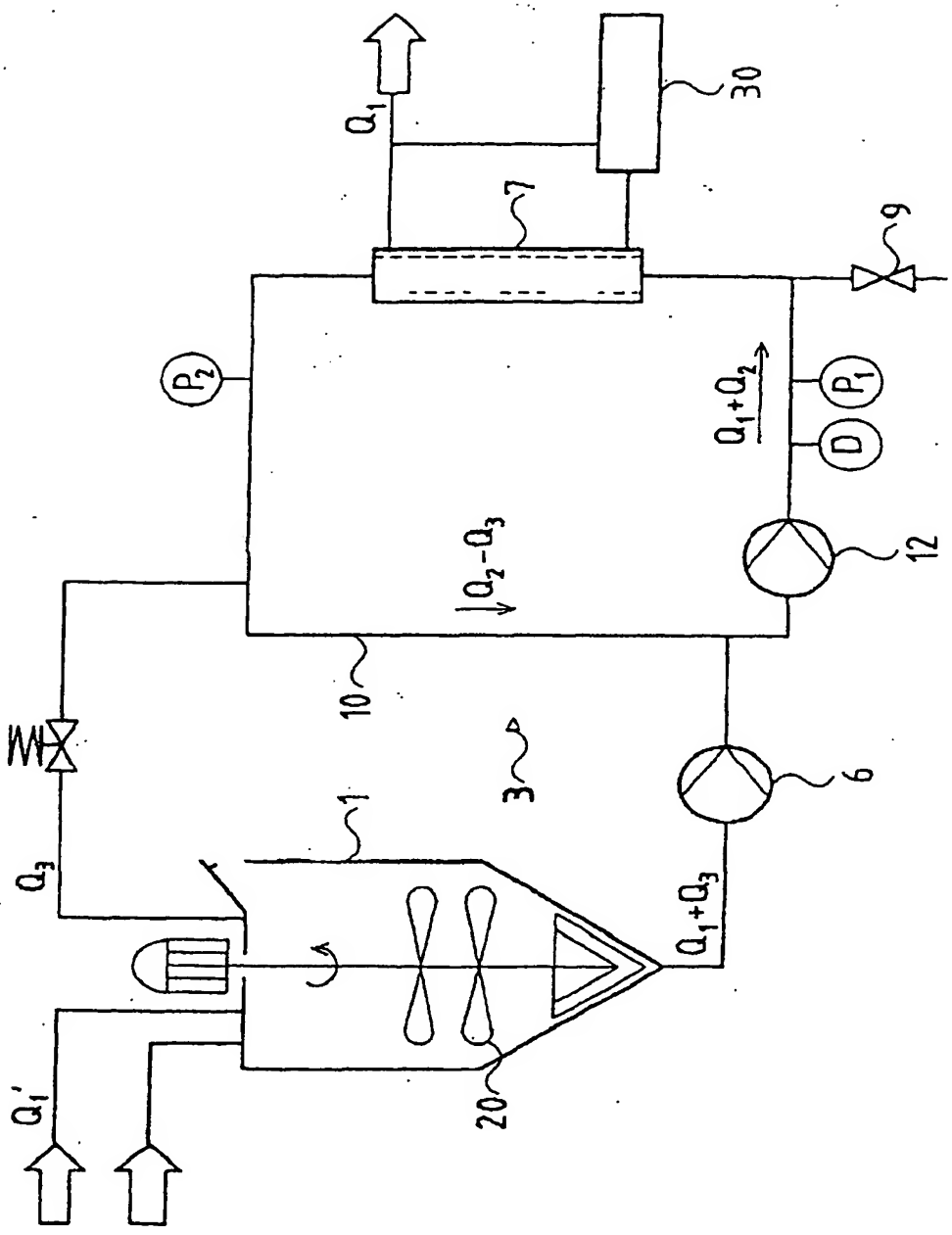

FIG. 2

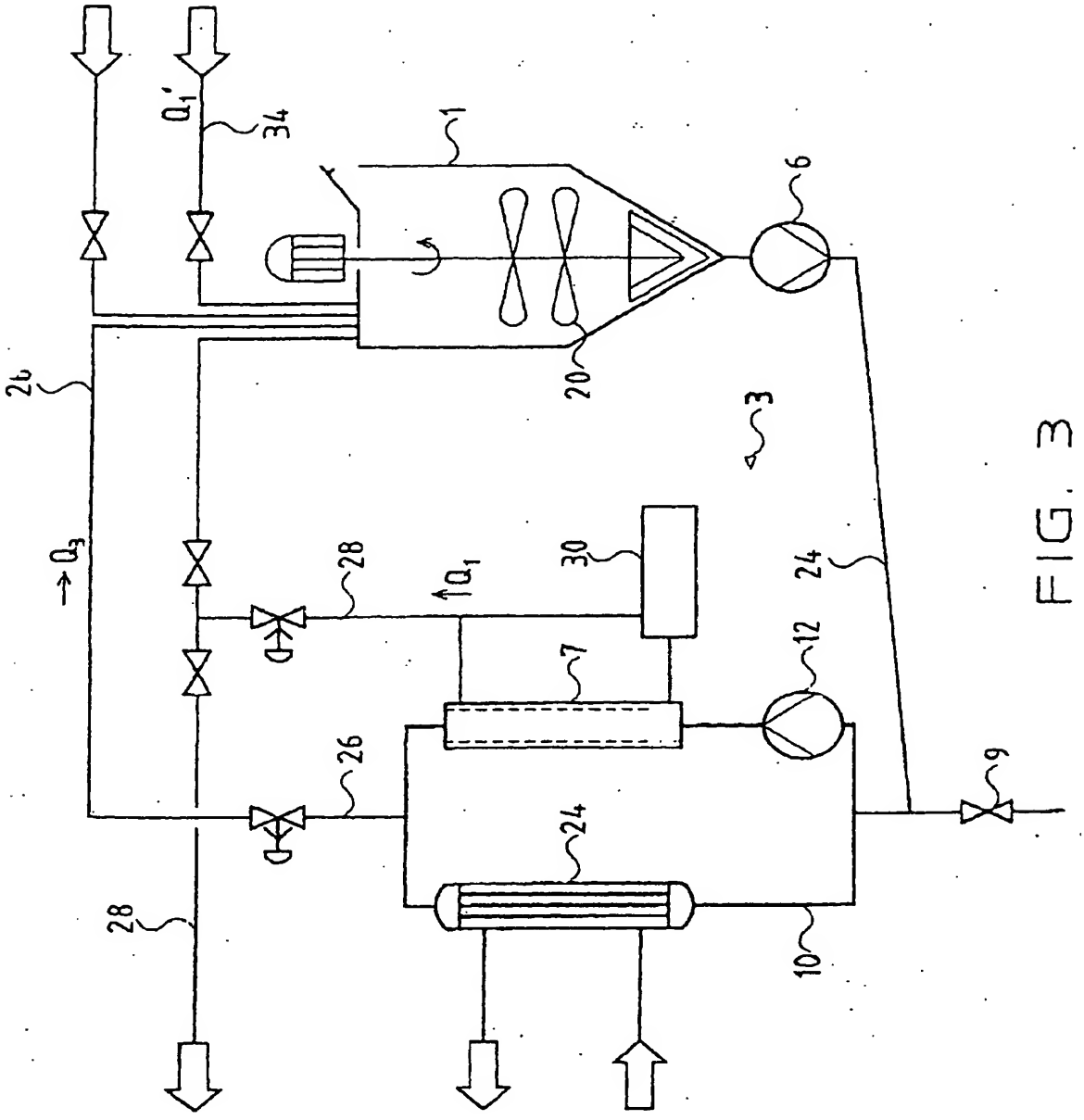

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 10 0885

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X,D	DE 198 06 796 A (MEMBRAFLOW GMBH & CO KG FILTER) 9 September 1999 (1999-09-09)	15-19	C22B3/22 C22B11/00
Y	* column 1, line 1 - line 32; claims 1,7-15; figures 1-5 *	1-14, 20-22	B01D61/14 B01D61/18 C01G55/00
Y	DD 293 142 A (TECH HOCHSCHULE C SCHORLEMMER) 22 August 1991 (1991-08-22) * page 1; figure 1 *	20-22	
X	US 5 266 203 A (MUKHOPADHYAY DEBASISH ET AL) 30 November 1993 (1993-11-30)	15-22	
Y	* column 1, line 44 - column 6; claims 1-9; figures 1-3 *	1-14	
Y	US 5 753 125 A (KREISLER LAWRENCE) 19 May 1998 (1998-05-19) * column 8; claims 1,9; examples 3,4 *	1,2, 20-22	
X	EP 0 263 953 A (RUHRCHEMIE AG) 20 April 1988 (1988-04-20)	15-22	
Y	* claims 1-6; figures 1,2 *	1,2,7,14	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
X	EP 0 829 752 A (KONISHIROKU PHOTO IND) 18 March 1998 (1998-03-18)	15-19	C22B B01D
Y	* page 18, line 49 - page 19, line 41; figures 1-3 *	8-14	C01G
A	DATABASE WPI Section Ch, Week 198040 Derwent Publications Ltd., London, GB; Class A88, AN 1980-71155C XP002168599 & SU 716 985 A (SYNTH TAR RES INST), 28 February 1980 (1980-02-28) * abstract *	1,14,15	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 May 2001	Bombeke, M

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Application Number
EP 01 10 0885

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	DATABASE WPI Section Ch, Week 199620 Derwent Publications Ltd., London, GB; Class M25, AN 1996-199554 XP002168600 & SU 1 734 388 A (AS USSR FAR E MINING INST), 10 September 1995 (1995-09-10) * abstract * -----	2,12,15, 20	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19806796 A	09-09-1999	AU 3250699 A	06-09-1999
		DE 19980247 D	12-10-2000
		WO 9942203 A	26-08-1999
DD 293142 A	22-08-1991	NONE	
US 5266203 A	30-11-1993	NONE	
US 5753125 A	19-05-1998	WO 9934926 A	15-07-1999
		US 5908559 A	01-06-1999
		AU 5732798 A	26-07-1999
EP 0263953 A	20-04-1988	DE 3630587 A	10-03-1988
		AT 65781 T	15-08-1991
		DE 3771822 A	05-09-1991
EP 0829752 A	18-03-1998	EP 1033615 A	06-09-2000
		JP 10123640 A	15-05-1998
		US 5928853 A	27-07-1999
SU 716985 A	25-02-1980	NONE	
SU 1734388 A	10-09-1995	NONE	

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